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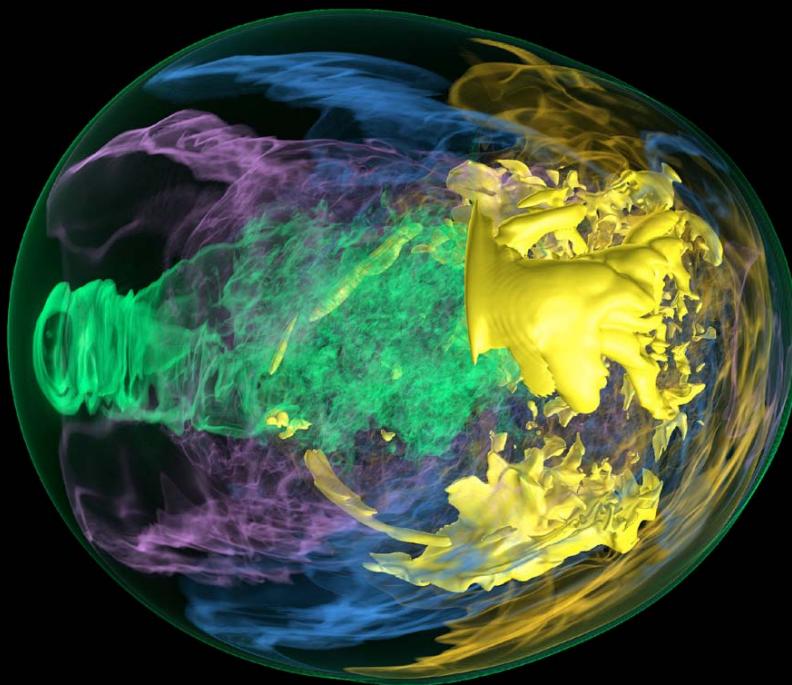
U.S. Department
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Parallel Volume Rendering on the IBM Blue Gene/P



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Intro: Wanted - € 50 Reward



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Tom Peterka, ANL

Intro: Supercomputer software rendering

- Déjà vu?

Bigger graphics clusters?

- Cost of scalability
- Power, cooling, space
- Not a rendering bottleneck

Availability

- Short runs available ad hoc
- Longer runs scheduled
- Dedicated resources

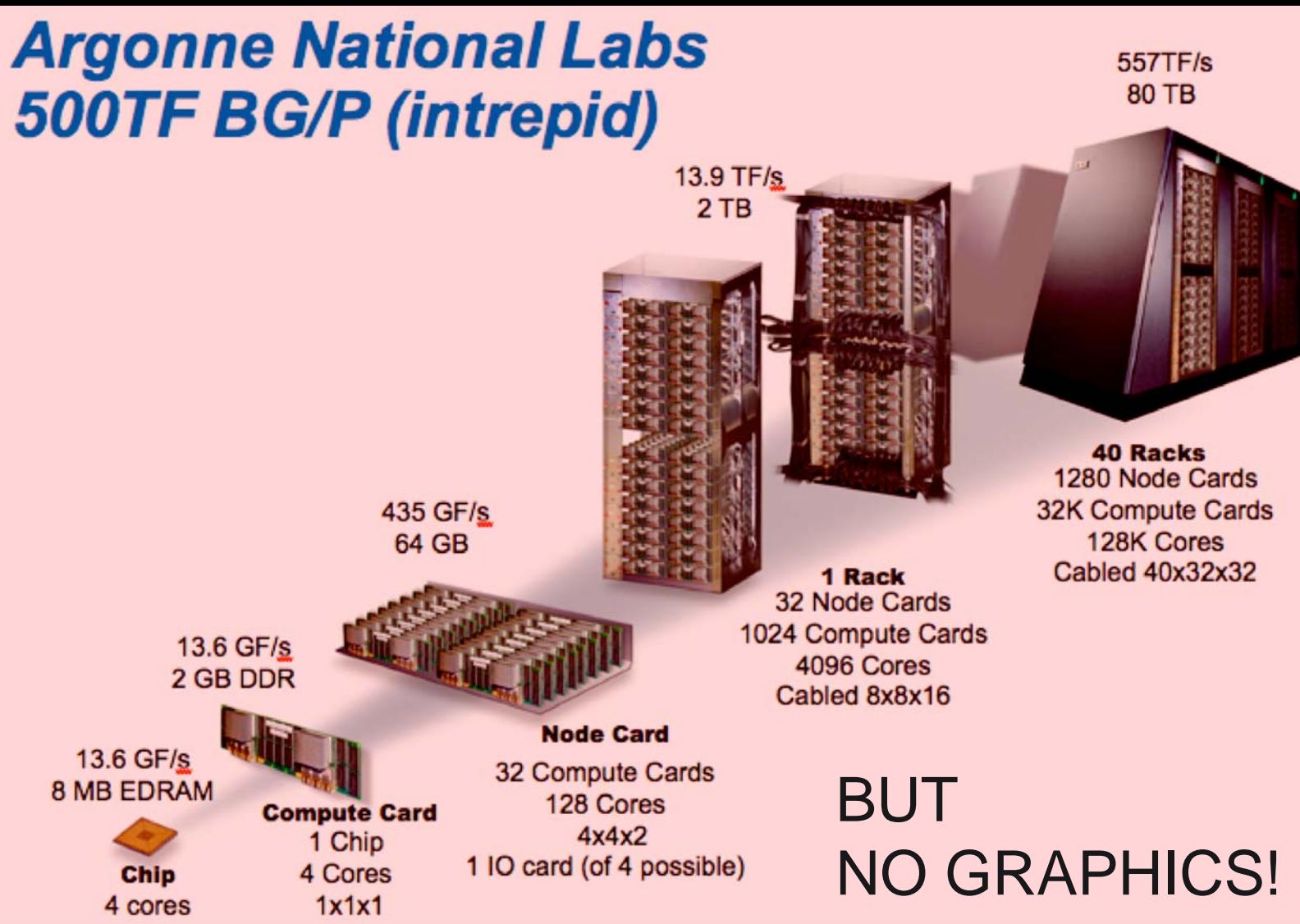
Cost effectiveness

- Short runs easy to schedule
- Backfill available cycles
- Policy decisions



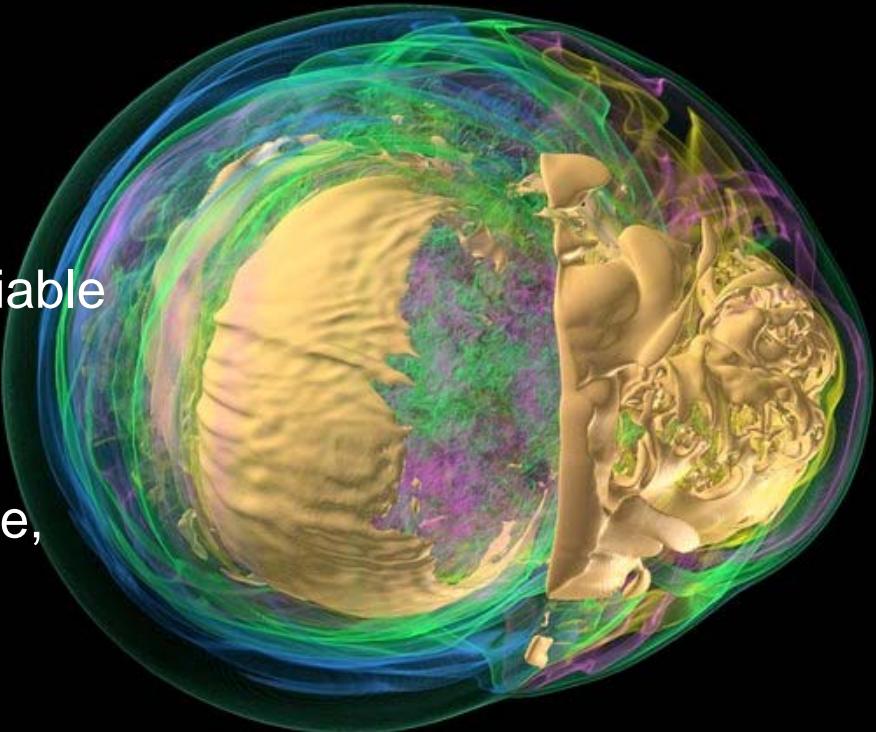
Background: Big iron

Argonne National Labs 500TF BG/P (*intrepid*)



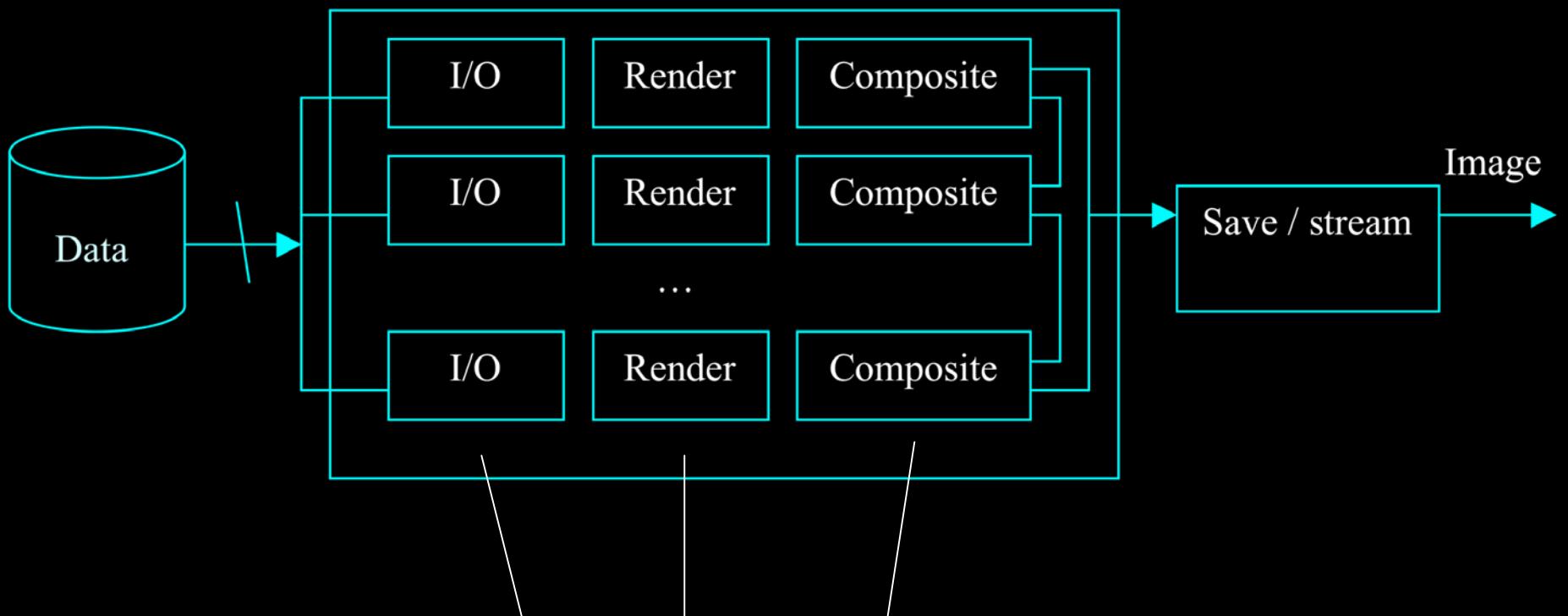
Background: Data

- Supernovae shock wave
- Structured grid
- 864^3
- 5 variables in netCDF
- Preprocess to extract single variable
- Time-varying, 200 time steps
- Each time step 2.5 GB
- Courtesy John Blondin, NC State,
and Tony Mezzacappa, ORNL



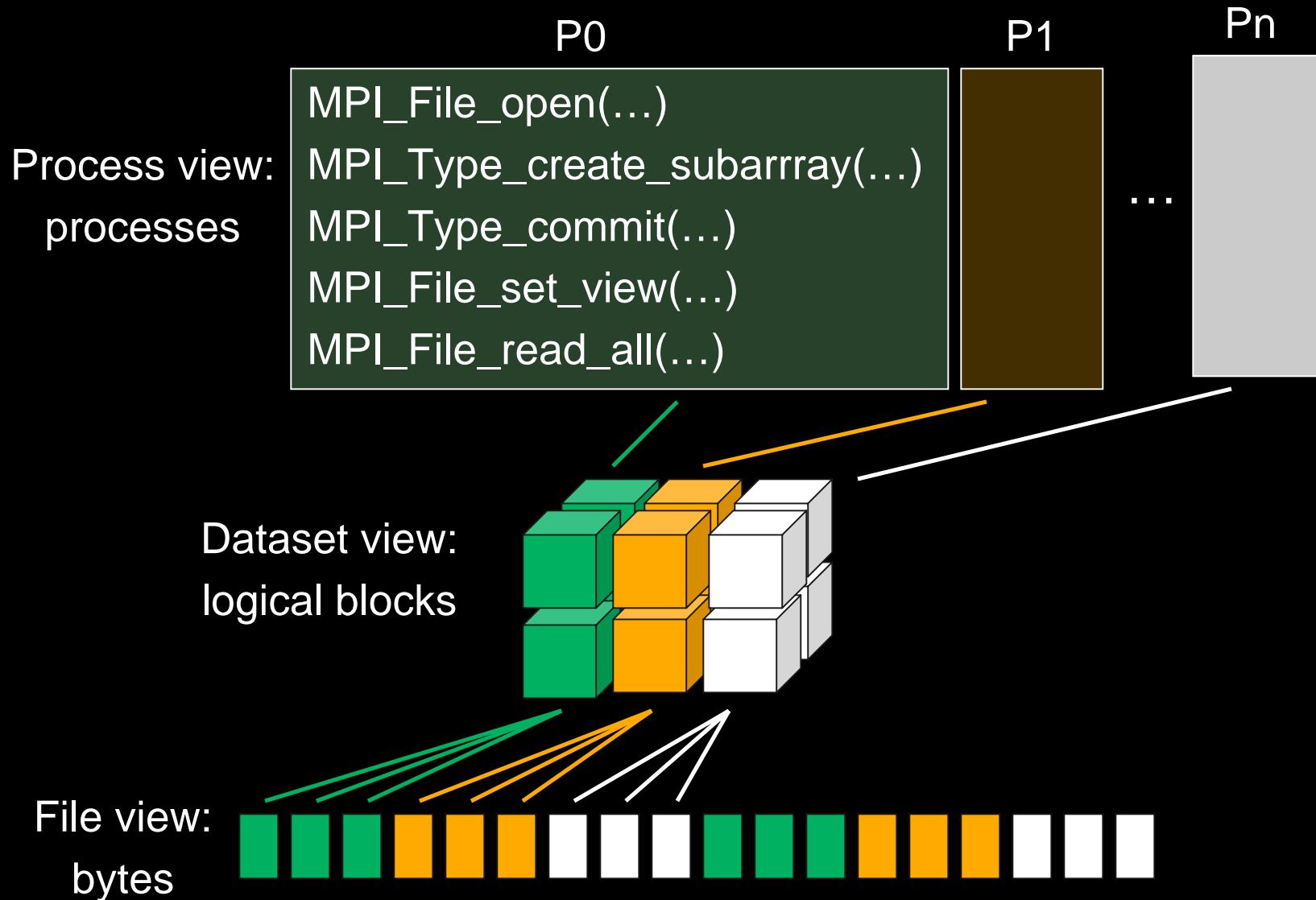
Background: Parallel volume rendering

- MPI programming model
- Distributed memory



$$t_{frame} = t_{io} + t_{render} + t_{composite}$$

Implementation: Data distribution & I/O

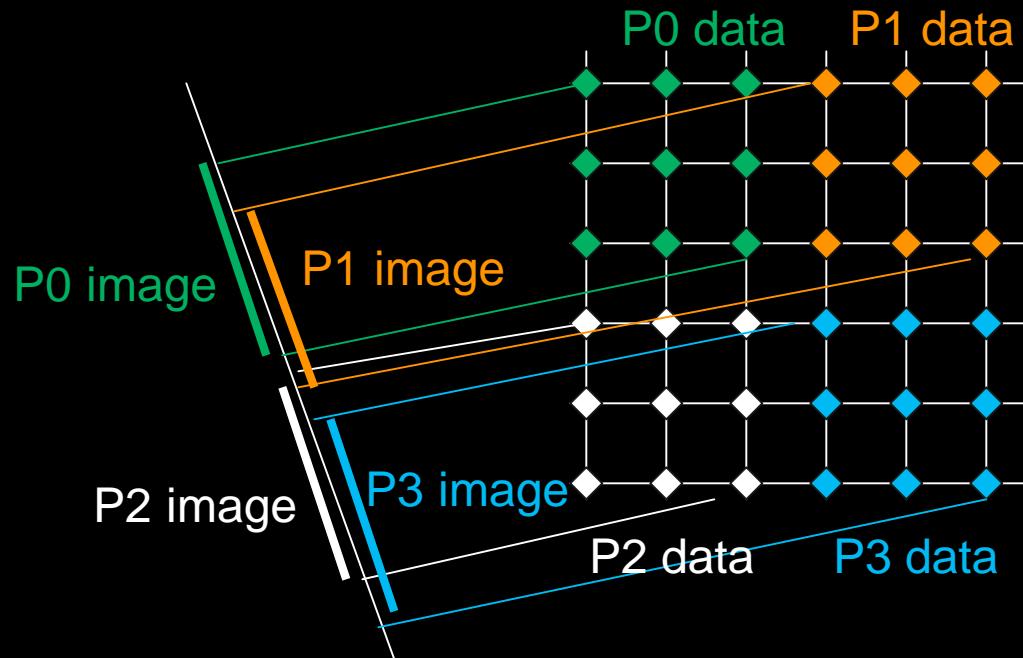


Implementation: Ray casting

- Trilinear interpolation
- Front-to-back color, opacity accumulation
- Early ray termination
- Static data partition
- Each process completes subimage of its subvolume data

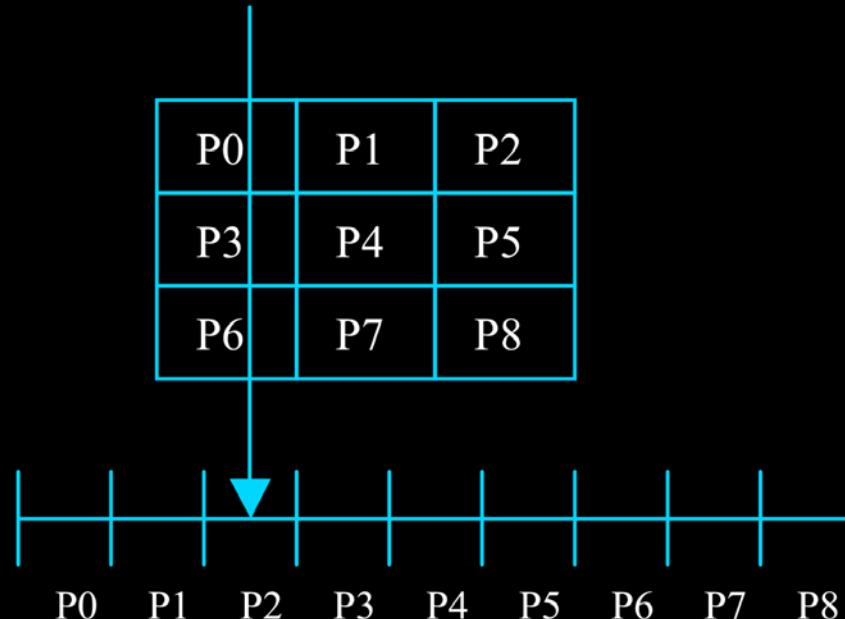
$$i = (1.0 - \alpha_{old}) * i_{new} + i_{old}$$
$$\alpha = (1.0 - \alpha_{old}) * \alpha_{new} + \alpha_{old}$$

where $i = \text{intensity}$, $\alpha = \text{opacity}$

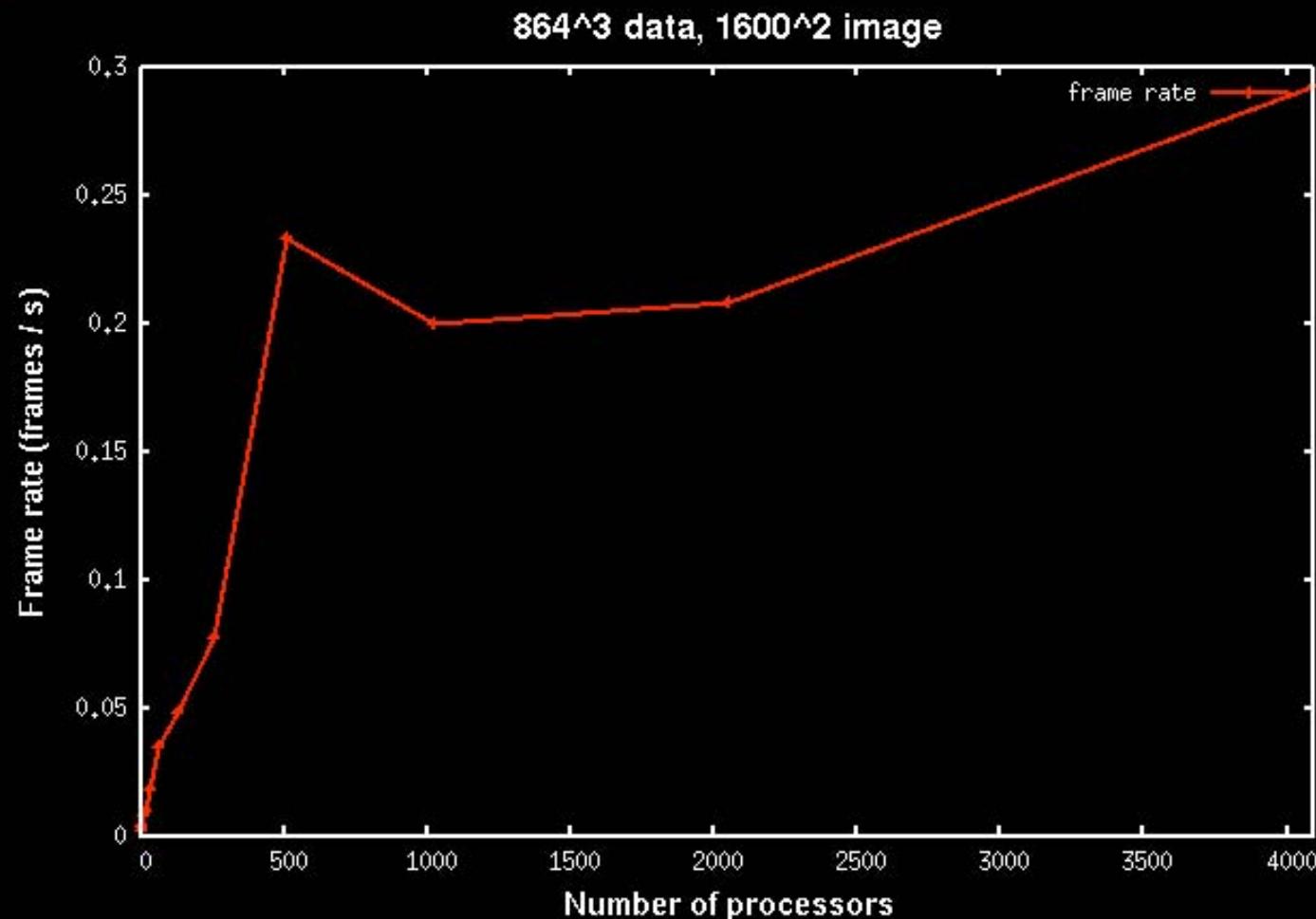


Implementation: Direct-send compositing

- Load balanced
- Non-scheduled
- $O(n^{4/3} + n)$ where $n = \text{number of cores}$
- $O(m)$ where $m = \text{number of pixels}$



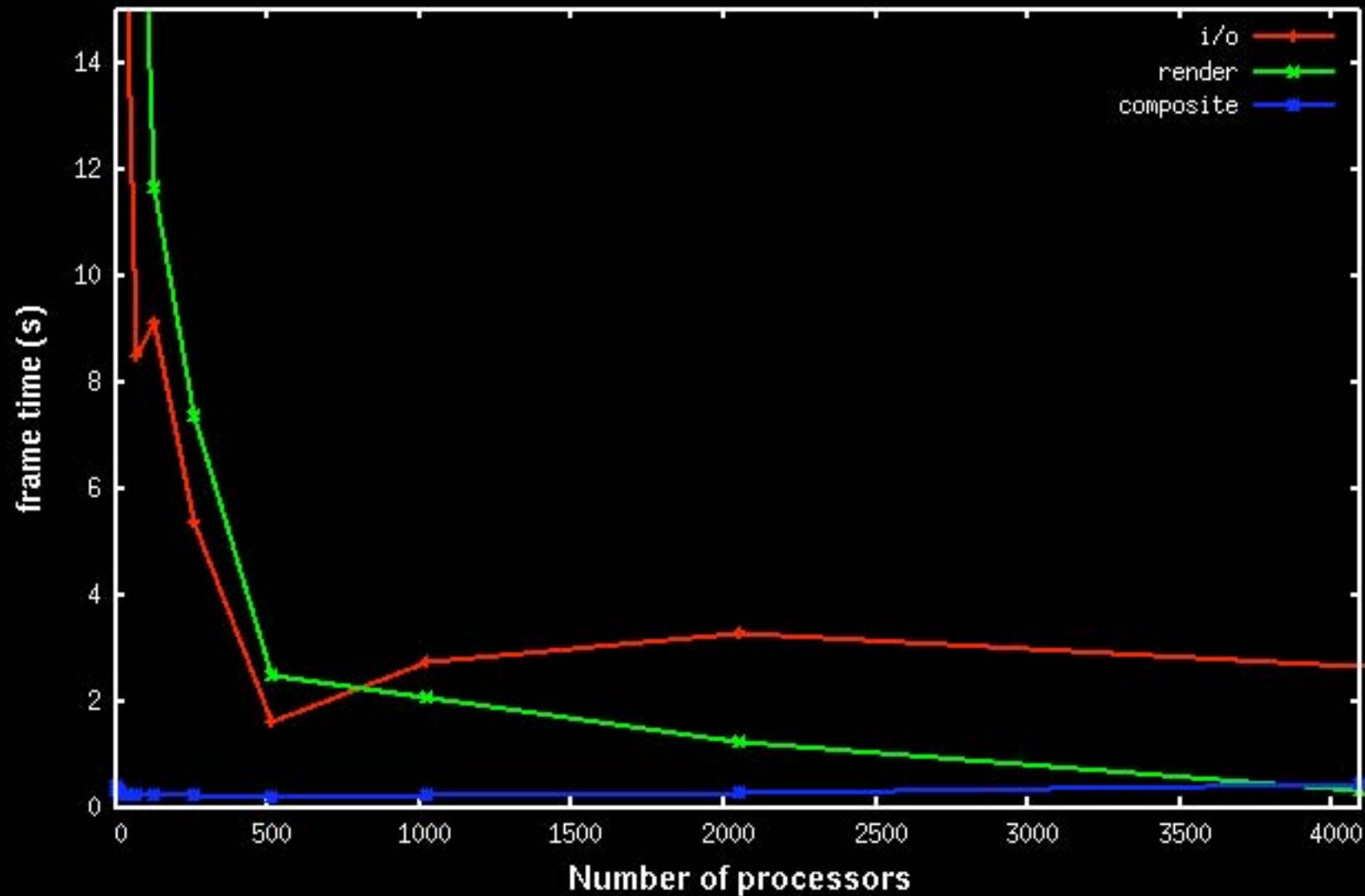
Results: Strong scaling



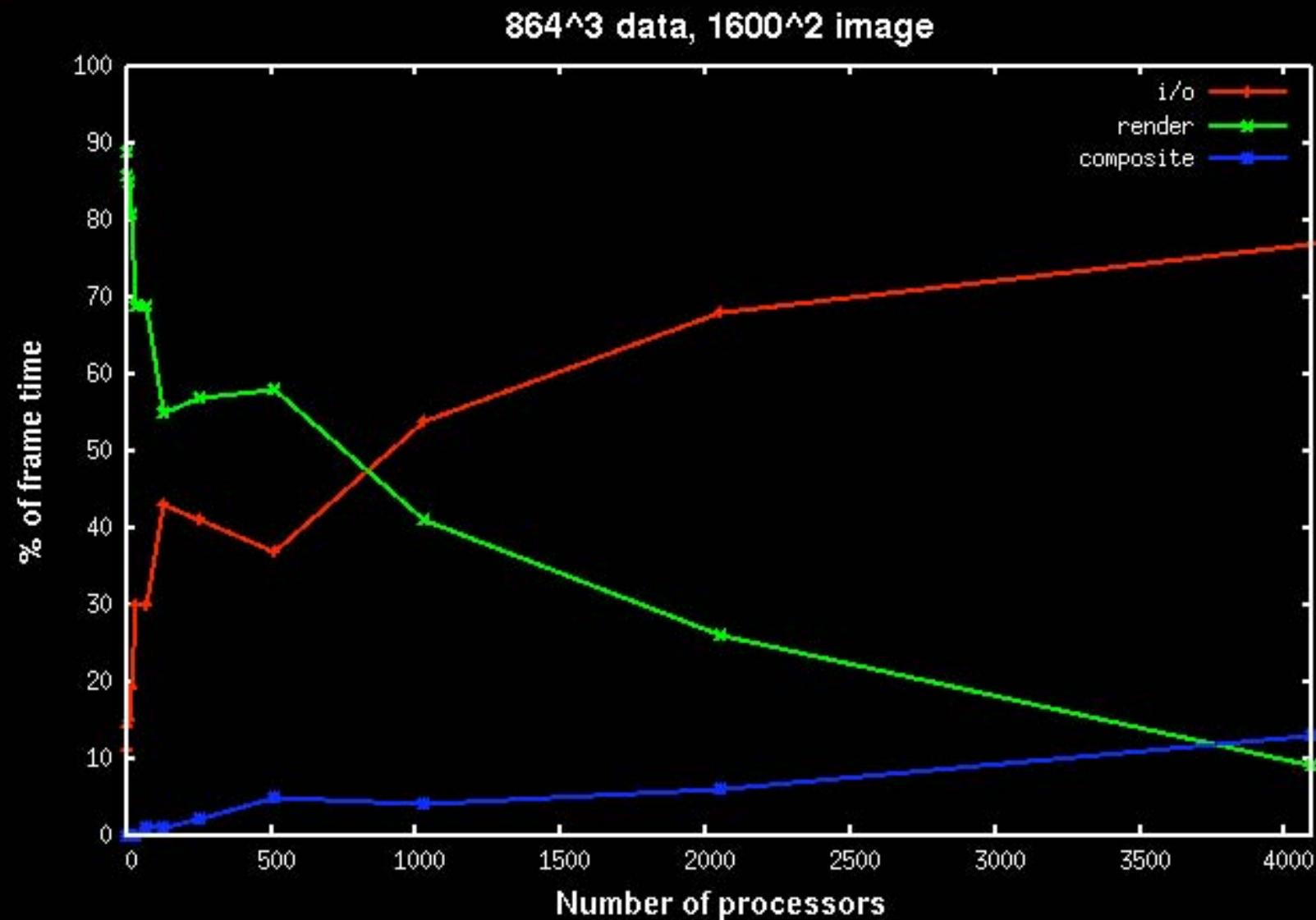
- End-to-end results, including file I/O
- Vis-only time .8 s

Results: Absolute time distribution

864³ data, 1600² image

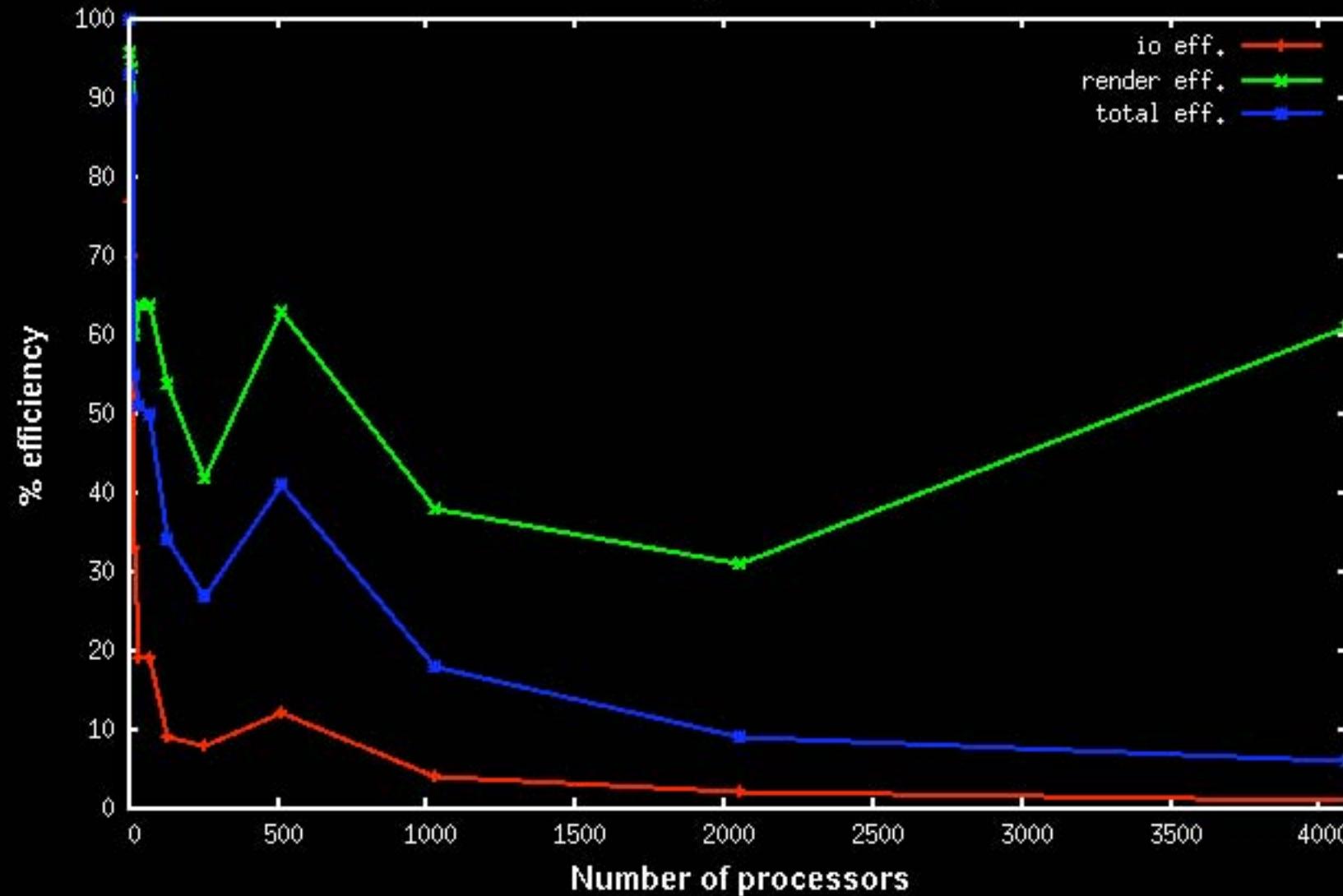


Results: Relative time distribution



Results: Efficiency

864³ data, 1600² image



Results: Improved efficiency



Conclusions

Successes

- Visualization on leadership machines at ultrascale
- End-to-end performance is a delicate balance
- I/O matters (E2E time, not just rendering time)
- Combination of systems and visualization solutions

Current work

- Load balance
- Hiding I/O cost
- Improved image quality
- Larger data

Future work

- Less structured data
- Interaction
- Novel display environments
- Exploit multi-cores
- Other architectures



Questions and challenges

Technical

- Compositing
- Interactivity
- In situ visualization:
implementation

Nontechnical

- Machine availability
- Machine utilization
- In situ visualization:
collaboration





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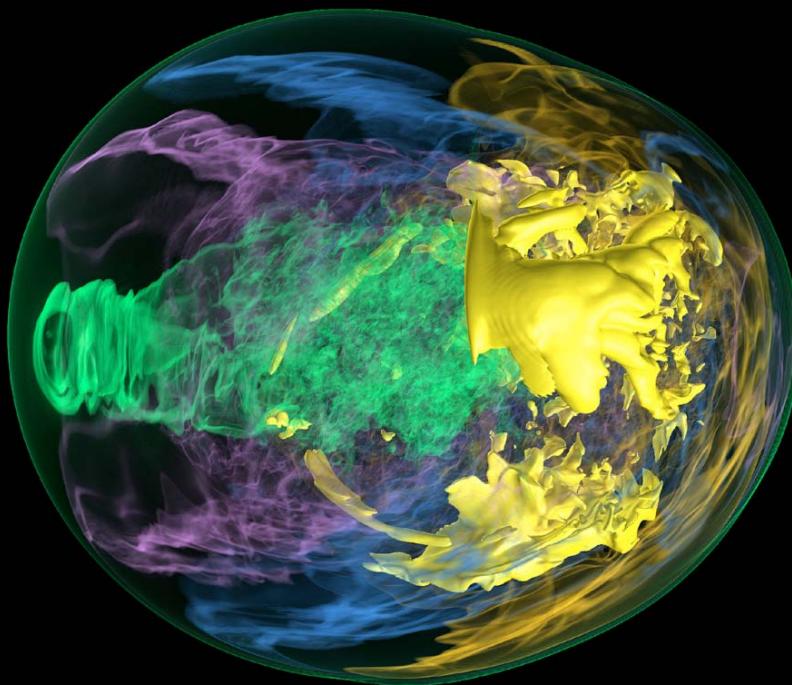
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